

EVIDENCE FOR REGIONAL BASIN FORMATION IN EARLY POST-TESSERA VENUS HISTORY: GEOLOGY OF THE LAVINIA PLANITIA AREA (V55); J. W. Head¹ and M. A. Ivanov², 1- Brown Univ., Providence, RI 02912 USA, 2- Vernadsky Inst. 117795, Moscow, Russia.

INTRODUCTION AND BACKGROUND. On Venus, global topography shows the presence of highs and lows including regional highly deformed plateaus (tesserae), broad rifted volcanic rises, linear lows flanking uplands, and more equidimensional lowlands (e.g. Lavinia and Atalanta planitiae) [1]. Each of these terrain types on Venus has relatively distinctive characteristics, but origins are uncertain in terms of mode of formation, time of formation, and potential evolutionary links [2]. There is a high level of uncertainty about the formation and evolution of lowlands on Venus. Do the lowlands represent initial stages in downwelling [3] which ultimately lead to compression and plateau building? Do the present basins represent these first stages which are on the verge of changing to another phase? Or do they represent some other mechanism, perhaps unrelated to a major evolutionary sequence producing other terrain types? We have undertaken the mapping of a specific lowlands region of Venus to address several of these major questions. Using geologic mapping we have tried to establish: What is the sequence of events in the formation and evolution of large-scale equidimensional basins on Venus? When do the compressional features typical of basin interiors occur? What is the total volume of lava that occurs in the basins and is this similar to other non-basin areas? How much subsidence and downwarping has occurred after the last major plains units?

We have undertaken an analysis of the geology of the V55 Lavinia Planitia quadrangle in order to address many of these issues and we report on the results here. From a topographic standpoint, Lavinia Planitia (45, 345) can be approximately defined by the -0.75 km contour; it is an equidimensional lowland basin about 2000 km in maximum dimension. The deepest parts of the basin are of the order of 1.5 km below mean planetary radius. Although the basin is broadly bowl-shaped, it is crossed by a number of distinctive topographic ridges (Hippolyta, Antiope, Molpaida, and Penardun lineae); these are ridge and fracture belts [2,4] that produce topographic highs with as much as one km of relief from the surrounding plains on the basin floor. To a first order, the basin floor is dominated by volcanic plains which consist of a variety of smooth bright and dark plains, plains populated with small shields, and digitate plains with distinctive linear flow lobes. The vast majority of plains are characterized by superposed wrinkle ridges. Virtually no major shield volcanoes exist within the basin, although the abundant small shields clearly represent numerous local sources. Also characteristic of the floor of the basin are numerous narrow linear graben that form parallel swarms of a variety of lengths and widths. Wrinkle ridges and fractures and ridge and fracture belts often intersect each other at high angles [4]. The margins of Lavinia Planitia are dominated by three major types of terrain. To the northeast, *tessera terrain* occurs in the form of Alpha Regio [5], and some patches of tessera terrain occur along the eastern margin. Along the eastern and southern margin of Lavinia a distinctive rift-fracture-corona chain parallels the edge of the basin and dominates the geology there [6]. These bear some similarity to other fracture belt/corona chains such as that of Parga/Themis [7]. One of the most prominent coronae is Eve, and at least some of the plains in the basin are derived from centers along this zone (e.g., Mylitta Fluctus) [8-9]. To the south of the Kalaipahoa Linea portion of the corona belt occurs Quetzalpetlatl Corona, an 800 km diameter structure which dominates the region south of the southern margin of the basin. The third major terrain type is the *broad volcanic rise* of Dione Regio, which is characterized by relatively high topography and several major shield volcanoes [10]. The characteristics of these marginal areas present a strong contrast to the topography and geological structure within the basin. Pioneer-Venus gravity data revealed a negative gravity anomaly (-30 mGal) and a negative geoid anomaly (-10 m); these were seen to be centered over the north-northeast part of the basin, corresponding approximately to the center of distribution of ridge and fracture belts. No distinctive major positive gravity anomalies were seen immediately adjacent to the basin [11].

STRATIGRAPHIC & STRUCTURAL SEQUENCE. The stratigraphic sequence according to our mapping is as follows: Tessera is well developed in Alpha Regio and may underlie larger parts of the quadrangle, but definitive exposures and thus evidence of its presence is lacking over most of the quadrangle. One of the oldest units in Lavinia is densely fractured material which sometimes displays a gradual transition to tessera-type structural patterns. Older plains (Pdf, Pfr, Psh) are cut by NW-trending graben. Medial plains (Pwr) flood the fracture and ridge belts and are deformed by wrinkle ridges. Younger plains (Pl) include the fluctus, which appear as floods with few domes, and mostly emerge from sources in the adjacent rift and coronae belt to the east and south [6, 8]. The youngest units are the dark parabola craters; older craters are observed and one of them in the quadrangle is embayed by lava of the digitate flows.

The interpreted geologic history starts with formation of the tessera from preexisting units of undetermined origin. Volcanism prior to downwelling produced background plains which were deformed by subsidence of the basin. Deformation belts (white linear units in Fig. 1a) formed by buckling of strong upper crust in response to subsidence. Subsequent volcanism (some Psh, but primarily Pwr) produced extensive volcanic plains between and among the deformation belts apparently from sources within the basin. These sources appear to be widespread

because of the large number of widely dispersed small shield volcanoes. The plains that filled the depressions between the deformation belts were in turn deformed by wrinkle ridges (Pwr). The paleogeology at the time just after the emplacement of Pwr is shown in Fig. 1a. The latest volcanism (shown in black in Fig. 1b) issued from centers located along the edge of the basin (associated primarily with the extensive rift zone extending for 6000 km along the western and southern margin of Lavinia Planitia; [6]) and flowed into the basin; intrabasin sources at this time are not obvious. We believe that these structural features and this stratigraphic sequence supports models which suggest that mantle downwelling first produces a topographic low and deformed the crust into ridges. Late-stage marginal rifting and volcanism may be related to upwelling counterflow linked to the general downwelling [e.g., 6]. The lack of abundant evidence of features that might be linked to small-scale mantle instabilities (e.g., coronae, large volcanoes) in central Lavinia appears to support the general downwelling model [3,11].

On the basis of the correlation of this sequence with the general geologic sequence established over many parts of Venus [12], we find that the vast majority of the topography in the basin (deformation belts, etc.) occurred prior to the formation of the plains with wrinkle ridges (Pwr; Fig. 1a), and certainly before the lobate plains (PI) which clearly flow down the margins of the basin into the interior (Fig. 1b). Plains with wrinkle ridges are the most widespread plains unit on Venus and their age of emplacement must be close to the general crater retention age of the planet (about 300-500 Ga) [12, 13]. Thus, these stratigraphic data suggest that the basin was formed closer to the period of tessera formation than to the present, and that much of Lavinia Planitia topography represents a relict topography inherited from this earlier period of more intense deformation.

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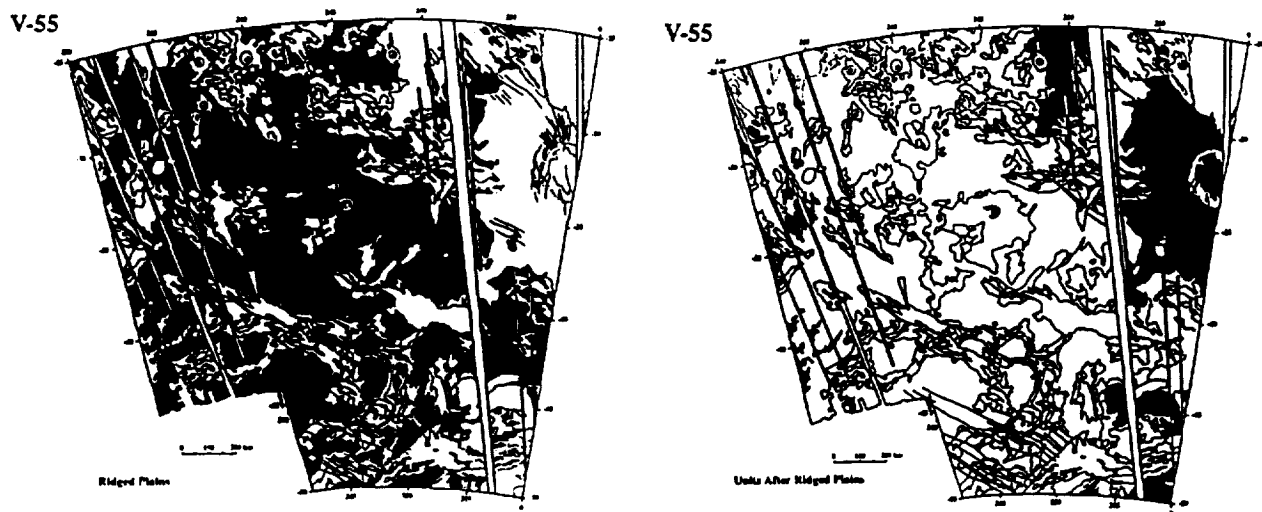


Figure 1. Paleogeologic maps showing the distribution of a) plains with wrinkle ridges (Pwr) superposed on early deformation belts, and b) lobate and digitate plains (PI), entering the already-formed basin from the margins.